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Reply by Authors to P.R. Payne

K.R. Reddy* and B.W. Roberts†
University of Sydney, Sydney, Australia

WE HAVE read Payne's comments with interest, and it is agreed that the papers in question are initial steps towards understanding the aerodynamics of some idealized, inflatable structures. Roberts considered an inflating, two-dimensional parabolic shell, while Reddy examined a two-dimensional, wedge-shaped shell.

We chose these types of structures as only one parameter, namely h or α, is necessary to completely define the structural shape at any instant of time. In other words, the structure is in its most elementary form and exists as a single degree-of-freedom system. If one was to consider an inelastic, membrane structure we would need an infinite number of degrees of freedom to completely define the structure's shape.

Therefore, we wished to idealize the structure in this manner so that the way was clear for a detailed consideration of the unsteady flow about such bodies. It is not intended that the structural or the aerodynamic argument be exactly applicable to the parachute, but it is not unreasonable to see that Reddy's structure is physically realizable as a hinged flat plate. This hinged plate is capable of aerodynamic inflation. The parabola, on the other hand, is only a mathematical artifice.

Now both these elementary structures can be mapped using well known conformal transformations. From these functions is is possible to calculate the pressure distribution on the structure as a function of α, $\dot{\alpha}$, $\ddot{\alpha}$, β, and $\dot{\beta}$ in Reddy's notation. Thus we have the pressure distribution on the structure as a function of two variables α and β. Reddy has then considered in his concluding example that the freestream velocity approaching the wedge is constant, that is $\beta=1$, $\dot{\beta}=0$, and this assumption is only an approximation to the infinite mass case. With this assumed form for β, Reddy only needed *one* structural equation to solve for $\alpha(t)$, and this appears as Eq. (14) in his paper. It must be stressed that this is a moment equation applied about the hinge. In this manner we have simultaneously satisfied the *structural and aerodynamic equations* without any recourse to a filling time notion.

The whole thrust of our argument does not depend on any filling time postulate given in some prior literature. Indeed, this same filling time notion is also *assumed* by Payne in Eqs. (2) and (3) of his Ref. 7. We would claim that such an assumption should not be necessary nor is it reasonable. We should also stress that Reddy's Eq. (15) is a *moment equation* which is only loosely coupled to the virtual mass, etc., of the canopy in *translational motion*. For instance, c_1 in Reddy's Eq. (15) is the virtual moment of inertia of the system, c_2 is the damping moment derivative, and so on. These latter quantities relate to *rotation about the hinge not translation of the wedge.* We feel that this aspect may not have been emphasized enough in our work, and we regret any possible confusion.

We make it quite clear that we accept Payne's criticisms relating to our neglect of the line stiffness, canopy elasticity, etc. Furthermore, the virtual mass referred to in Sec. V of Payne's comment is in fact buried in $\int pds$ of Reddy's Eq. (14), and the virtual mass can be found from the appropriate terms in Reddy's integral or in Wang and Wu's paper, "Small Time Behaviour of Unsteady Cavity Flows."[1] In conclusion, we agree with Payne's last paragraph and add that even a simple, hinged flat plate is a structure which is dynamically coupled with the fluid flow in a rather complex matter.

Finally it is our intention to present at the next AIAA Aerodynamic Deceleration Systems Conference, Nov. 17-19, 1975, an analysis of an n degree-of-freedom hinged system. This latter approach we believe is not an "ultra - simplified model of the canopy flow," nor an unreasonable structural model.

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*Research Student, Department of Mechanical Engineering

†Senior Lecturer, Department of Mechanical Engineering. Member AIAA.

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